

This Page Is Inserted by IFW Operations
and is not a part of the Official Record

BEST AVAILABLE IMAGES

Defective images within this document are accurate representation of
The original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images,
please do not report the images to the
Image Problem Mailbox.**

THIS PAGE BLANK (USPTO)

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
12 July 2001 (12.07.2001)

PCT

(10) International Publication Number
WO 01/50704 A2

- (51) International Patent Classification⁷: H04L 29/00 Ronald, H.; 42 Huckleberry Lane, North Andover, MA 01845 (US).
- (21) International Application Number: PCT/US00/33215
- (22) International Filing Date: 7 December 2000 (07.12.2000)
- (25) Filing Language: English
- (26) Publication Language: English
- (30) Priority Data:
09/477,113 31 December 1999 (31.12.1999) US
- (71) Applicant: SCHNEIDER AUTOMATION INC. [US/US]; One High Street, North Andover, MA 01845 (US).
- (74) Agent: GOLDEN, Larry, I.; Square D Company, General Patent Counsel, 1415 South Roselle Road, Palatine, IL 60067 (US).
- (81) Designated States (*national*): CA, MX.
- (84) Designated States (*regional*): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).
- Published:
— Without international search report and to be republished upon receipt of that report.
- (72) Inventors: PAPADOPOULOS, A., Dean; 11 Rooks Run, Groton, MA 01450 (US). TANZMAN, Allan; 37 Westsex Road, Newton Center, MA 02459 (US). NAISMITH,
- For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

(54) Title: DUAL ETHERNET STACK FOR MAXIMUM SPEED ACCESS TO A PLC

(57) Abstract: A control system includes an Internet web interface to a network of at least one programmable logic control system running an application program for controlling output devices in response to status of input devices. The Web interface runs Web pages from an Ethernet board coupled directly to the PLC back plane and includes an HTTP protocol interpreter, a PLC back plane driver, a TCP/IP stack, and an Ethernet board kernel. The Web interface provides access to the PLC back plane by a user at a remote location through the Internet. The interface translates the industry standard Ethernet, TCP/IP and HTTP protocols used on the Internet into data recognizable to the PLC. Using this interface, the user can retrieve all pertinent data regarding the operation of the programmable logic controller system.

WO 01/50704 A2

DUAL ETHERNET STACK FOR MAXIMUM SPEED ACCESS TO A PLC

5

TECHNICAL FIELD

Applicants' invention relates generally to the field of programmable controllers and more particularly to a system for coupling a network of programmable controllers through an internetwork to a monitoring and control device.

10

RELATED APPLICATIONS

This application is a continuation-in part of U.S. Patent Application No. 09/303,458 which is a continuation-in-part of U.S. Patent Application No. 08/927,005. This application is also related to the following commonly assigned applications entitled "Apparatus for Controlling Internetwork Communications," U.S. Patent Application No. 08/926,837 and "Messaging Application Layer (MODBUS) Over Ethernet to Transport Layer (TCP) Communications Method and Apparatus for a Modular Terminal Input/Output System," U.S. Patent Application No. 09/166,870. The contents of these Applications are expressly incorporated herein by reference.

15

20

BACKGROUND OF THE INVENTION

Remote monitoring and control of systems and processes have taken many forms. In the past, dedicated lines became the most common form of communication between a control system and a remote location. This has limited application since the control system was not accessible from multiple

5

locations. Modems have made it possible to access the control system from different locations, but these types of systems are generally restricted to downloading and uploading data files. Providing any type of control function between locations is rather limited in this type of environment. Further, an
5 end user generally required a customized interface to access the control system.

With the growth of Internet, and its World Wide Web providing a deliver platform for organizing Internet data through hypertext links, a client server system can be designed that will give each end user the same type of
10 a user friendly interface with the same universal access to services on the Web. The Web is a network of documents called sites or pages stored on server computers throughout the world. Each page will usually contain text, some type of multimedia offerings such as graphic images, video, or audio, and possible hypertext links to other documents. A browser allows a user to
15 read the pages and interact with the choices associated with it. The browser is a graphical software program that sends commands to the Internet Web site and displays whatever information is available on the page. Various browser programs are commercially available from different manufacturers.

The Internet network employs methods designed to handle thousands
20 of general purpose computers sharing a single cable, and therefore has no ability to differentiate traffic in terms of its purpose or the criticality of its data. The Internet is no longer a network of computers sharing a single cable, but rather a web of interconnected point to point links involving both general purpose stations and specialized infrastructure components such as routers
25 and firewalls.

The type of personal computer or work station used by the end user to connect to the Web is of no regard. Communication over the Internet and other networks requires one of several types of protocols. Protocols such as Internet Protocol (IP) provide for file transfers, electronic mail, and other

services. A Sun Microsystem programming language known as Java, along with Hypertext Markup Language (HTML) used in designing layouts and graphics for a Web site or page has extended Internet technology such that a web site can be used for dynamic applications, commonly called applets, 5 that can be downloaded and run by the end user. These applets are interpreted and run within a Web browser and have been generally restricted to word processing and similar uses. Downloading and running applets can be slow in comparison to other types of compiled languages. Security rules imposed on a browser and enforced by the underlying JAVA language prevent applets 10 from obtaining certain data from any other device other than the Web server itself.

Programmable logic controllers (PLCs) are widely used in industry and process control. Many manufacturers provide factory automation information using Microsoft Windows and other types of communication 15 networking environments. These networks are usually slow, are not universally accessible and are limited to monitoring and data exchange. Control may be implemented, but since the communication networks are non-deterministic, control is not real time. Specialized industrial networks using proprietary fieldbus alternatives can be very expensive. Conversion 20 products are required to allow information carried over those networks to be visible on a general purpose network. There are significant installation and other deployment costs associated with the existence of such intermediate devices. Firewalls between the Web server and the application are designed to solve problems of security and are not designed for high performance.

25 It would be desirable to develop an automation control system whereby an user could use general, commercial networks such as the Internet in place of specialized industrial networks to remotely monitor automation control devices such as PLCs.

It is also desirable, as communication networks become faster and more data is interchanged by PLCs in the operation of a control system, to create the fastest method of transporting data possible. The faster the means of communication between a PLC device and its I/O devices the more closely a process can be controlled. Additionally, high speed communication between PLCs can be accomplished to closely couple a distributed control application. However, as data transfer becomes faster improved methods of receiving, processing and transmitting that data must be developed in order to implement it.

SUMMARY OF THE INVENTION

Other features and advantages of the invention, which are believed to be novel and nonobvious, will be apparent from the following specification taken in conjunction with the accompanying drawings in which there is shown a preferred embodiment of the invention. Reference is made to the claims for interpreting the full scope of the invention which is not necessarily represented by such embodiment.

BRIEF DESCRIPTION OF THE DRAWINGS

Figure 1 shows an overview block diagram of a typical system illustrating the relationship between an user at a remote location and an Internet Web site used for monitoring a process control system according to the present invention.

Figure 2 is a basic block diagram of the present invention illustrating an Internet interface to a programmable logic controller system.

Figure 3 is a block diagram of the Web server module illustrated in Figure 2 according to the present invention.

Figure 4 is a typical mimic page available to a user at a remote location utilizing a browser which illustrates the present invention for monitoring a programmable controller system.

5 DETAILED DESCRIPTION

Although this invention is susceptible to embodiments of many different forms, a preferred embodiment will be described and illustrated in detail herein. The present disclosure exemplifies the principles of the invention and is not to be considered a limit to the broader aspects of the
10 invention to the particular embodiment as described.

Figure 1 shows an overview block diagram of typical system illustrating the relationship between an user 2 at a remote location and an Internet web site 4 used for monitoring a process control system 6. The user 2 will have a personal computer (PC) 8 having a commercially available
15 browser 10, such as Netscape Communication's Navigator or Microsoft's Internet Explorer, installed for viewing the contents at the web site 4 by a monitor 12 through a network, such as the Internet 14. The PC provides a remote human-machine interface (HMI) to the process control system 6. Various interconnection services are readily available to provide the physical
20 and electrical interconnection from the PC to the Internet 14 itself. The Internet 14 is a collection of independent world wide communication networks that are interconnected to each other and function as a single connectionless entity. Communication is based on a client-server basis, using a number of established protocols that allow for communication and file
25 transfers between the client and the server. The most widely used protocol is Internet Protocol (IP).

The web site 4 includes a network interface 16 having an unique Internet address 18, a server 20, and an application program 22. The server 20 acts as a hypertext transfer protocol (HTTP) interpreter which uses

Transmission Control Protocol (TCP) in conjunction with Internet Protocol, through a Transmission Control Protocol/Internet Protocol (TCP/IP) stack 24 to interact with the network interface 16 and the application program 22. This enables the data transfer between the application program 22 and the user 2 through the Internet 14. The application program provides data from the process control system 6. This data can be used to monitor the control process by the user 2 at the remote location. The stack 24 enables data transfers over the Internet 14 between the user 2 and the web site 4 as required for the various layers specified by the IP protocol.

10 The user 2 can connect to the Internet 14 using one of a number of Internet service providers and will enter the address of the web site 4 when connected. The web site 4 will display a home page which may contain text, some type of multimedia offerings such as graphic images, video, or audio, and possible hypertext links to other documents. The browser 10 will allow
15 the user 2 to read the page and interact with the choices associated with it. The browser 10 will send commands to the web site 4 which will use the application program 22 to display whatever information is available from the process control system 6. The browser 10 functions as a remote human-machine interface or HMI control of the process control system as
20 will be detailed below.

Figure 2 shows a basic block diagram of the present invention illustrating the Internet interface to a programmable logic controller system. The web site 4 includes the network interface 16 having an unique Internet address 18 and a web server 30. The web server 30 provides the home page
25 for the website. A firewall or security for the overall system can be included in the web server 30, but is generally maintained as part of the network interface 16. In addition to providing security for various pages at the site, the user can disable the web server 30. A password and user list is provided in initial configuration files stored in the web server 30 that are downloaded

from a remote server. Protection of the configuration file is then provided by the remote server and the web server 30 through the password and the user list. The web server 30 provides a direct connection for a programmable logic controller (PLC) 32 to the Internet 14 by plugging the web server 30 into its back plane 34. The web server 30 provides both a client and server interface. All signals between the PLC 32 and the web server 30 are through the back plane 34 rather than over a set of cables which would normally have to be coupled to input/output modules that are themselves plugged into the back plane 34. The back plane signals include addressing, control, data, and power. The client interface allows a user to send commands to a remote node over the Internet and the server interface allows for processing commands that originated from a remote node. Controlling the PLC 32 from a remote HMI, essentially on a real time basis is possible by controlling the data flow through the web server 30.

Associated with the PLC 32 are its application programs 36, dual port memory 38 and Input/Output (I/O) modules 40. The application programs 36 include a ladder logic program for controlling the I/O modules 40. The web server 30 functions as a node on a TCP/IP network 42 allowing it to send commands to the PLC 32 and receive the response. Although the TCP/IP network 42 in the preferred embodiment is an Ethernet network, other high level protocols could be used. Using a web browser at a remote location through the Internet 14, a user can control and view configuration information of the PLC 32.

The web server 30 is shown in greater detail in Figure 3. Various components provide the required connectivity to perform its functionality. A real time operating system 44 controls the interaction between the components. The operating system 44 allocates processor time on a central processor unit (CPU) 46 to various tasks, provides memory management, and provides a set of message services and signal services. The message and

signal services allow for communication between tasks, and between drivers and a task.

Connection to the TCP/IP network 42 is through an Ethernet driver 48 which transmits and receives messages at a rate of 100 Mbs (megabits per second) or faster via an Ethernet communication chip 49, such as, in the case of 100 Mbs Ethernet, a Crystal CS8952 available from Cirrus Logic, Inc. It is contemplated that in the future Ethernet communication chips capable of speeds of 1 Gbs (gigabits per second) and faster can be used. The physical connection over which communication is facilitated can be over a fiber optic cable or a twisted pair-type copper wire. However, the physical connection must be capable of transmitting the signal at 100 Mbs or faster. In the case of 100 Mbs Ethernet over twisted pair-type copper wire, the copper wire and wire connections must conform to at least the Category 5 copper wire standard.

Alternatively, the TCP/IP stack 24 could be replaced by a dual TCP/IP stack. The dual TCP/IP stack comprises a first TCP/IP stack which provides support for a broad range of TCP/IP messages. The first stack is preferably a standard SENS stack from Wind River, Inc., although any commercially available TCP/IP stack is adaptable to the present invention. The second TCP/IP stack is a "short stack" which manages high priority control messages between the PLC 32 and I/O modules 40. The second stack is optimized to handle very specific TCP/IP messages, in this instance Modbus on Ethernet, in order to process the specific message in the most efficient manner possible.

For outgoing TCP/IP messages, the appropriate TCP/IP stack would be chosen by an application program 36 associated with the PLC 32. On incoming TCP/IP messages, the TCP/IP message would be intercepted and examined to see if: 1) it is a TCP/IP message, 2) that is intended for the Modbus on Ethernet protocol (i.e. is the source protocol the Internet Assigned

Number for the Modbus on Ethernet Protocol of 502), and 3) is the destination port above a specified number (3072). If it is a TCP/IP message intended for the Modbus on Ethernet protocol, then the message is delivered to the second stack. If it is not a TCP/IP message intended for the Modbus on Ethernet protocol, the first TCP/IP stack handles the message. In this manner, TCP/IP messages intended for the Modbus on Ethernet protocol are handled more quickly and efficiently than when a single TCP/IP stack is implemented.

The web server will have a unique global address 18, allowing it to be addressed by other devices on the network. The Ethernet driver 48 manages transmit 50 and receive 51 buffers in memory 52, and interfaces with the Ethernet communication chip 49. The transmit 50 and receive 51 buffers are shared both by the Ethernet communication chip 49 and the Ethernet driver 48. The Ethernet driver 48 also provides a transmit request interface and a receive indication interface to a TCP/IP stack 54. The Ethernet communication chip 49 provides a transmit queue interface, a receive queue interface, and generates interrupts on completion of transmitting a message, and on receiving a new message. The Ethernet driver 46 places receive buffers in the receive queue. In the interrupt routine, the Ethernet driver 46 examines the receive queue. If any messages are in the receive queue, it passes the receive buffer to the TCP/IP stack 54. The TCP/IP stack 54 copies the buffer, and sometime later calls the Ethernet driver 48 to return the buffer and place the returned buffer back into the receive queue.

The TCP/IP stack 54 calls the Ethernet driver 48 to transmit a message. The Ethernet driver 46 attempts to allocate a buffer from the shared memory 52. If it succeeds, it copies the message into the buffer, and places the buffer into the Ethernet communication chip 49 transmit queue. If there is no transmit buffer, then the driver drops the transmit message. In the

interrupt routine, the Ethernet driver 48 examines the transmit queue, and frees the transmitted buffers.

The TCP/IP network 42 allows special MSTR (master) functions that allow nodes on the network to initiate message transactions. These MSTR
5 functions include reading and writing data and are used for commands and responses. They allow programs running in the PLC 32 to send commands to a remote node on the TCP/IP network 42 and receive the responses. A back plane driver 56 sends commands and receives the response to the PLC 32 over the back plane 34.

10 The back plane driver 56 receives request from the PLC's ladder logic MSTR blocks stored in its memory 38. When a response is available, the back plane driver 56 passes it back to the MSTR block. The back plane driver 56 provides a client task 58 and server task 60 to the applications. The server task 60 interface allows an application to issue a request command to the
15 PLC's 32 executive program and receive its response. The client task 58 allows an application to receive a new MSTR request and pass back the response to the ladder logic program.

The server task 60 uses a queuing mechanism and call back functions. An application queues both the request and the call back function associated
20 with the request. When the back plane driver 56 services the request in its interrupt routine, it calls the associated call back function. The response and the original request is passed to the call back function. The call back function can call an operating routine to either pass a message or signal the application.

25 The client task 58 also uses queues and call back functions. The client application queues both an indication request on queue and a call back function associated with the request. When the back plane driver 56 detects a new MSTR block request in its interrupt routine, it calls the associated call back function. The request is passed into the call back function. The call back

function can call an operating system routine to either pass a message or signal the application. If the back plane driver 56 detects that the MSTR block has been aborted, or is no longer being solved, it calls an user supplied associated abort call back function. The application calls a routine to pass the
5 MSTR response and an associated call back routine to the driver. Sometime later, the driver passes back the response to the ladder logic program in its interrupt service routine, and then calls the user supplied call back function.

The PLC 32 interfaces with the web server 30 hardware via the dual port memory 38. It reads and writes to the dual port memory 38 using an
10 ASIC chip. Writing to a specified location will cause an interrupt. The PLC 32 first writes a message in the dual port memory 38, and then causes an interrupt. The message indicates a type of command. One type indicates that a MSTR block is being solved. Other types are used for passing requests to the PLC 32 and obtaining the responses to the requests. After the PLC 32
15 passes the message, it polls the dual port memory 38 for commands placed by the back plane driver 56. These commands are read memory, write memory, and processing is complete. The back plane driver 56 uses state machines to process the MSTR interrupts. The maximum number of active MSTR blocks is set at four in the present invention, requiring four state
20 machines. When the back plane driver 56 receives a MSTR interrupt, it attempts to find an associated state machine that matches with the MSTR block. If there are already four outstanding transactions, no more are available, and the back plane driver 56 will set the MSTR's outputs to false. If a state machine is found, the back plane driver 56 determines if it is a new
25 transaction, an outstanding transaction, or a response is available. If it is a new transaction it copies the request and calls the application's associated call back routine. If its an outstanding transaction, it indicates to the ladder logic program that the MSTR block is still busy. If a response is available,

the back plane driver 56 copies the response, sets either the MSTR's completion or error output, and calls the application's call back routine.

Two interrupts are used for processing a request. On the first interrupt, called the preport interrupt, the back plane driver 56 copies the request into a data structure located in the PLC's 32 dual memory 38. On the second interrupt, called the end of scan interrupt, the back plane driver 56 copies the response from the controller's data structure into the user's buffer. It then calls the user's associated call back function.

The request for accessing the PLC's 32 registers is processed by the back plane driver 56 and is not sent to the PLC's executive program for processing. The back plane driver 56 determines the memory location in the memory 38 of the registers the PLC 32. At an end of scan interrupt, the back plane driver 56 processes the read/write register requests by sending commands via the dual port memory 38 to the PLC 32 to read or write the locations containing the registers. The back plane driver 56 will service a maximum of four read/write register requests at the end of a scan interrupt.

A client task 58 interfaces with the TCP/IP stack 54, the back plane driver 56 and uses the operating system 44 message services. It processes the MSTR request. When the client task 58 receives a MSTR request from the back plane driver 56, it passes the request to the TCP/IP stack 54. When the TCP/IP stack 54 returns a response to the client task 58, it passes the response to the back plane driver 56. The TCP/IP stack 54 provides a Berkeley TCP/IP interface and a signal extension. The signal extension calls a user supplied function which passes in a socket number, a task ID, and an event. The signal function calls the operating system 44 to send a message to the task indicated by the task ID. It sends a message either to the client task 58 or server task 60. The client task 58 posts request indications to the back plane driver 56, and the associated call back routine calls the operating system 44 to send a message to the client task 58 for a new MSTR transaction.

The client task 58 manages multiple outstanding MSTR transactions using the state machines. There is a linked list of connection state machines. The connection state machines are used for establishing connection and closing connections. In addition each connection state machine contains a list of transaction state machines. Each transaction machine on the connection state machine represents a transaction to a node represented by the connection machine. The transaction machines are used to send a request, and process the response. The client task 58 enters a loop after performing initialization. It calls the operating system 44 to receive a message. The operating system will block the client task 58 until there is a message or until there is a time out. It either receives a message from the TCP/IP stack 54, from a MSTR call back routine, or it times out. It process the message or the time out and then reenters the loop. If the message received from the operating system 44 is a new MSTR request, the client task will obtain a connection state machine, and places a new transaction machine at end of the list of the connection state machine's list. At this point the transaction machine will attempt to transmit the message. It may not be possible to transmit the message because no connection has been established, or the because the remote side may have applied flow control.

If the message received from the operating system 44 is a TCP/IP event, the client task 58 finds the associated connection machine and determines if the TCP/IP event is an accepted connection, an aborted connection, or a received data event. Based on the connection state, and the transaction machine's state, the client task 58 processes the message to advance the transactions if there are any. Receiving data for the MSTR responses may occur over several TCP/IP events, and the transaction state machine assembles the data into a response. When the client task 58 requests the TCP/IP stack to transmit a message, not all of the message may be transmitted. This occurs when the remote node is flow controlled, which is

explained below. If the call to the operating system 44 to receive a message returns with a time out, or if there is a message, the client task 58 searches the list of connection machines that are flow controlled. For each flow controlled connection, it tries to advance the transaction state machines on the connection state machine list that are flow controlled.

The server task 60 processes a request originating from the user at the remote location. The server task 60 interfaces with the back plane driver 56, the TCP/IP stack 54, and the operating system's 44 message services. The server task 60 posts requests to the back plane driver 56, and an associated call back routine uses the operating system 44 message services to send the response to the server task 60. A TCP/IP stack 54 signal function also uses the operating system's 44 send service to send an TCP/IP event to the server task 60. The server task 60 can handle multiple transactions and connections. Like the client task 58, it maintains a list of connection machines, and each connection machine contains a list of transaction machines. The connection machines are for managing the connection and the transaction machines manage the incoming requests and responses.

The server task 60 enters a loop after performing initialization. It calls the operating systems 44 to receive a message. The operating systems 44 block the server task 60 until there is a message or until it times out. It either receives a message from the TCP/IP task's 54 signal handler, from the back plane driver 56 or it times out. It processes the message or the time and reenters the loop. If the message received from the operating systems 44 is from the TCP/IP task's 54 signal handler, the server task 60 determines if the event is a connection request, a close socket event, or a receive data event. Based on the TCP/IP event, the server task 60 uses the connection machine and transaction machine to advance the transaction. Received data for a request may occur over several receive data events, and the transaction machine assembles the events into a request message. When the response

message is received from the operating system 44, the server task 60 finds the connection and transaction machine in order to send the response.

5 When the server task 60 requests the TCP/IP stack 54 to transmit a message, not all of the message may be transmitted. This occurs when the remote node is flow controlled. If the call to the operating system 44 is to receive a message returns with a time out, or if there is a message, the server task 54 searches the list of connection machines that are flow controlled. For each flow controlled connection, it tries to advance the transaction state machines on the connection state machine list that are flow controlled.

10 After the server task 60 has parsed the header of an incoming request, it attempts to allocate a structure to pass the request to the back plane driver 56. If the server task is already processing a predetermined number of outstanding requests, the attempt fails, the connection is placed into a blocked state, and the body of the request is not read from the TCP/IP stack 54. As a result the TCP/IP stack may apply flow control to the remote node. When one
15 of the other requests is complete, the free data structure event causes a blocked connection machine to continue processing the incoming Modbus request.

The HTTP task 62 interfaces with the TCP/IP stack 54, and the back
20 plane driver 56. The HTTP server task 62 receives a HTTP request from the TCP/IP stack 54. To process the request, it may access the PLC 32 through the back plane driver 56 and back plane 34. The HTTP server task 62 sends back the response over the TCP/IP stack 54. The framework is supplied by the operating system 44. The framework creates the HTTP task, accepts
25 connection, and parses the HTTP request. After parsing the request, it calls the operating system 44 to process the request. Processing the request involves determining the request type and processing the actual request. The different request types allow a user to acquire a snapshot of the PLC 32 operations by allowing a view of various registers within the PLC 32 and

dual memory 38. These request types also include display of the PLC 32 configuration, remote and distributed I/O and module health statistics, display registers, back plane configuration, Ethernet statistics and others, as shown in Table 1:

5	Show the home page
	Show the programmable logic controller's configuration
	Show the Ethernet statistics
	Show the read register request page
10	Show the 4x registers
	Show the racks attached to the controllers back plane
	Send an image. The different images are gif files that are displayed on the various pages
	Show the remote I/O statistics
15	Show the list of configured remote I/O drops
	Show a remote I/O rack's configuration and health
	Show a remote I/O drop's communication statistics
	Show the I/O reference values of a remote I/O module
	Show a list of configured distributed I/O nodes
20	Show the configuration and the health of a distributed I/O node
	Show the I/O reference values of a distributed I/O module

TABLE 1

The home page contains hyperlinks to seven pages of data. The configuration page will display the configuration of PLC 32. The remote I/O and distributed I/O module health status pages are a series of linked pages. The first page displays the communication health statistics at the Remote I/O and Distributed I/O head and contains a link to a configured drop page. The configured drop page displays a table containing drop numbers which are

linked to a drop status page and rack numbers which are linked to the drop and rack configuration pages. Two tables are included in the drop status page, one for showing the communication status of the drop and the other for showing which racks are populated with the I/O modules. The drop and rack configuration page displays the I/O modules, their health, and slot location for the given rack. From a selected module, a user can view it's input and output values. Register data is displayed in a template having a form and a table, with the user entering an address and a length. The table will display the register's values. A table showing option modules and their slot location is displayed on the back plane configuration page. The data appearing on the pages is static but can be automatically updated at preselected times.

The operating system 44 processes these requests and responds by sending HTTP messages through the TCP/IP stack 54. Processing some of these requests involves reading the PLC's traffic cop, registers, coils, or various page zero locations where statistics are kept. To perform these reads, the operating system 44 sends a request to the back plane driver 56 and uses an event signal mechanism and event flags to determine when the request is complete. After sending the request to the back plane driver 56, the operating system 44 waits for an event flag to be sent. When the back plane driver completes the request, the back plane driver 56 calls a call back routine, which sets the event. The operating system 44 then resumes processing the request.

A mimic page which represents some of the hardware physically connected to a programmable logic controller system can be constructed utilizing various graphical programs readily available and that are not an object of the present invention. The present invention allows a user at a remote location, using a browser, to view the mimic page and actually control various components illustrated in the mimic page. Figure 4 shows a simple motor start-stop control in ladder logic diagram form that could be available

as a mimic page to the user. Pushing a motor start push button 150 will cause a motor start relay 152 to energize through a normally closed stop push button 154 and a normally closed overload contact 156. Auxiliary motor start contact 158 will latch relay 152 after the start push button 150 is released and pilot light 160 will illuminate. Auxiliary motor start contact 162 will provide power to pump motor 164 which will remain running until stop push button 154 is depressed or overload relay 166 detects an overload condition. In this example, start push button 150, stop push button 154, overload contact 156, auxiliary motor start contacts 158 and 162, and overload relay 166 are inputs to the programmable logic controller system. Relay 152, pilot light 160, and pump motor 164 are outputs. The PLC will have the registers containing the animation data for the inputs and outputs. An application program in the PLC will respond to the inputs to control the outputs

A user at a remote location will browse the Internet for the home page of the installation of the programmable logic controller system. The PLC will have other control functions as well and if the user has the necessary authorizations, various options will become available. The home page will allow the user to acquire a snapshot of the PLC operations by allowing a view of various pages that will allow access to registers within the PLC. Other pages will also include displays of the PLC's configuration, remote and distributed I/O modules health statistics, display registers, back plane configuration, Ethernet statistics and others as shown previously shown in Table 1.

The mimic diagram page will be called up on a browser screen which will allow the user to view the status of the system. The mimic diagram's light 160, relay 152, contacts 158, 162, and pump motor 164 will be updated to correspond to the state of the actual devices. The states of the inputs and outputs will then be shown on the ladder diagram which will be automatically updated as they are changed. Through the use of applets representing the start

150 and stop 154 buttons, the user could manually control start and stopping of the motor by using a mouse or keyboard to position a cursor and "clicking" on either the start 168 or stop 170 boxes.

5 While the specific embodiments have been illustrated and described, numerous modifications are possible without departing from the scope or spirit of the invention.

CLAIMS

We claim:

1. An interface module for receiving data requests from a remote location in order to provide access to a programmable logic controller from a communication network, the module comprising:
 - a central processing unit;
 - 5 a real time operating system operating the central processing unit;
 - a network interface for communicating with the communication network;
 - a back plane driver for communicating with the programmable logic controller through a back plane of the programmable logic controller;
 - 10 a dual protocol stack;
 - a client task for communicating with the back plane driver and the protocol stack for initiating received requests;
 - a server task for communicating with the back plane driver and the protocol stack for responding to received requests; and
 - 15 a protocol task for communicating with the back plane driver and the protocol stack for receiving and responding to protocol task requests.
2. The interface module of claim 1 wherein the communication network is a world-wide network known as the Internet using an Internet Protocol (IP).
3. The interface module of claim 2 wherein the interface module functions as a web site on the Internet, the interface module including a global IP address.
4. The interface module of claim 1 wherein the network interface is an Ethernet driver.

5. The interface module of claim 1 wherein the protocol stack is a Transmission Control Protocol stack.
6. The interface module of claim 1 wherein the protocol task includes a server task using a hypertext transport protocol (HTTP) to deliver hypertext documents to the network interface.
7. The interface module of claim 6 wherein the HTTP task accepts a connection, parses an HTTP request, and calls the real time operating system to process the request.
8. The interface module of claim 2 wherein the interface module allows a user at a remote location to view data within the programmable logic controller from a browser connected to the Internet.
9. The interface module of claim 1 wherein the dual protocol stack comprises a dual TCP/IP stack.
10. The interface module of claim 9 wherein the dual TCP/IP stack comprises a first stack capable of handling a broad range of TCP/IP messages and a second stack capable of handling a less broad range of TCP/IP messages more quickly than the first stack.

11. An interface module for receiving data requests from a remote location in order to provide access to a programmable logic controller from a communication network, the module comprising:

- a central processing unit;
- 5 a real time operating system operating the central processing unit;
- a network interface for communicating with the communication network at a nominal data transfer rate of not less than 100 Mbs;
- a back plane driver for communicating with the programmable logic controller through a back plane of the programmable logic controller;
- 10 a dual protocol stack comprising:
 - a first protocol stack for communicating a broad range of network messages;
 - a second protocol stack for quickly communicating a specialized set of network messages;
- 15 a client task for communicating with the back plane driver and the protocol stack for initiating received requests;
- a server task for communicating with the back plane driver and the protocol stack for responding to received requests; and
- a protocol task for communicating with the back plane driver and the
- 20 protocol stack for receiving and responding to protocol task requests.

12. The interface module of claim 11 wherein the communication network is a world-wide network known as the Internet using an Internet Protocol (IP).

13. The interface module of claim 12 wherein the interface module functions as a web site on the Internet, the interface module including a global IP address.

14. The interface module of claim 11 wherein the network interface is an Ethernet driver.

15. The interface module of claim 11 wherein the protocol stack is a Transmission Control Protocol stack.

16. The interface module of claim 11 wherein the protocol task includes a server task using a hypertext transport protocol (HTTP) to deliver hypertext documents to the network interface.

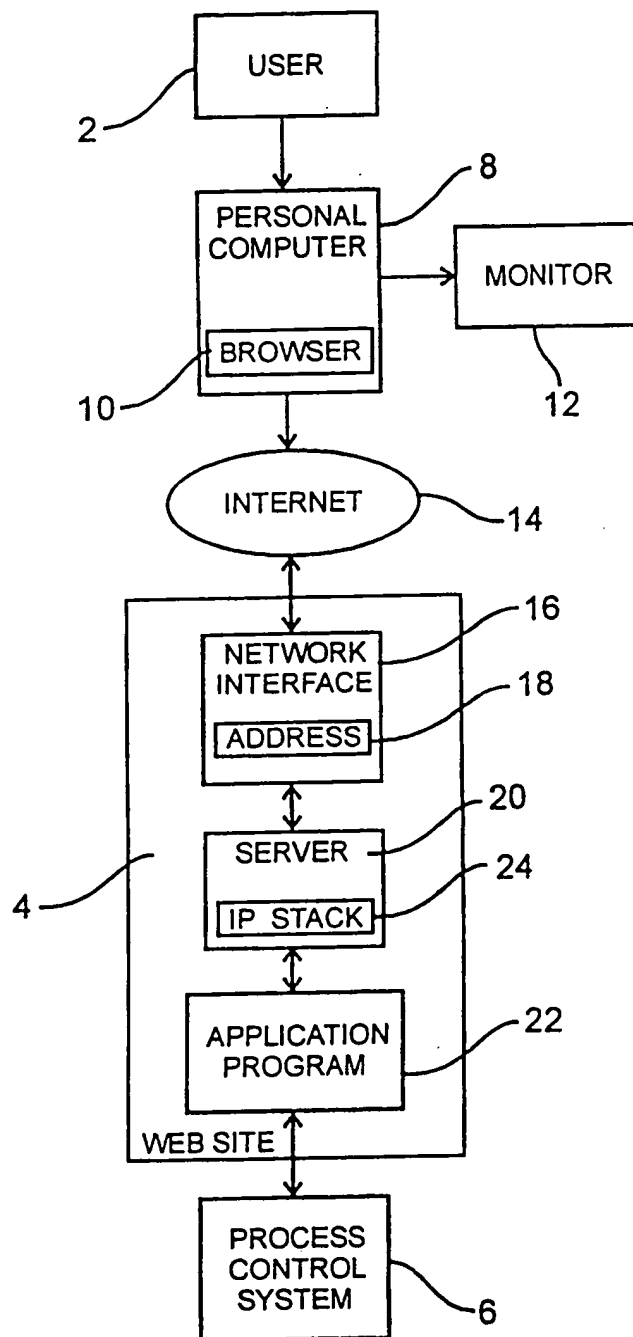
17. The interface module of claim 16 wherein the HTTP task accepts a connection, parses an HTTP request, and calls the real time operating system to process the request.

18. The interface module of claim 12 wherein the interface module allows a user at a remote location to view data within the programmable logic controller from a browser connected to the Internet.

19. The interface module of claim 11 wherein the first and second protocol stacks are TCP/IP stacks.

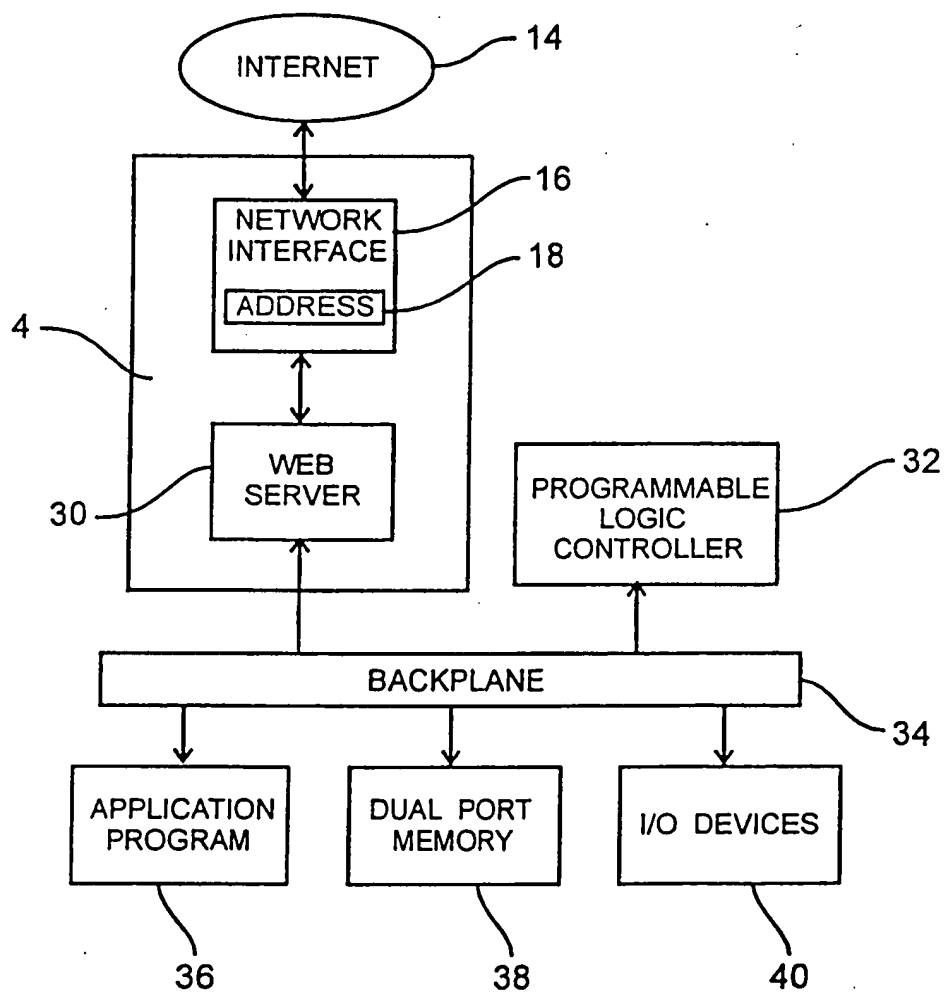
20. The interface module of claim 19 wherein the second protocol stack is implemented when source protocol is the Internet Assigned Number for the Modbus on Ethernet Protocol of 502 and the destination port is above a port number 3072.

1/4

*Fig. 1*

THIS PAGE BLANK (USPTO)

2/4

*Fig. 2*

THIS PAGE BLANK (USPTO)

3/4

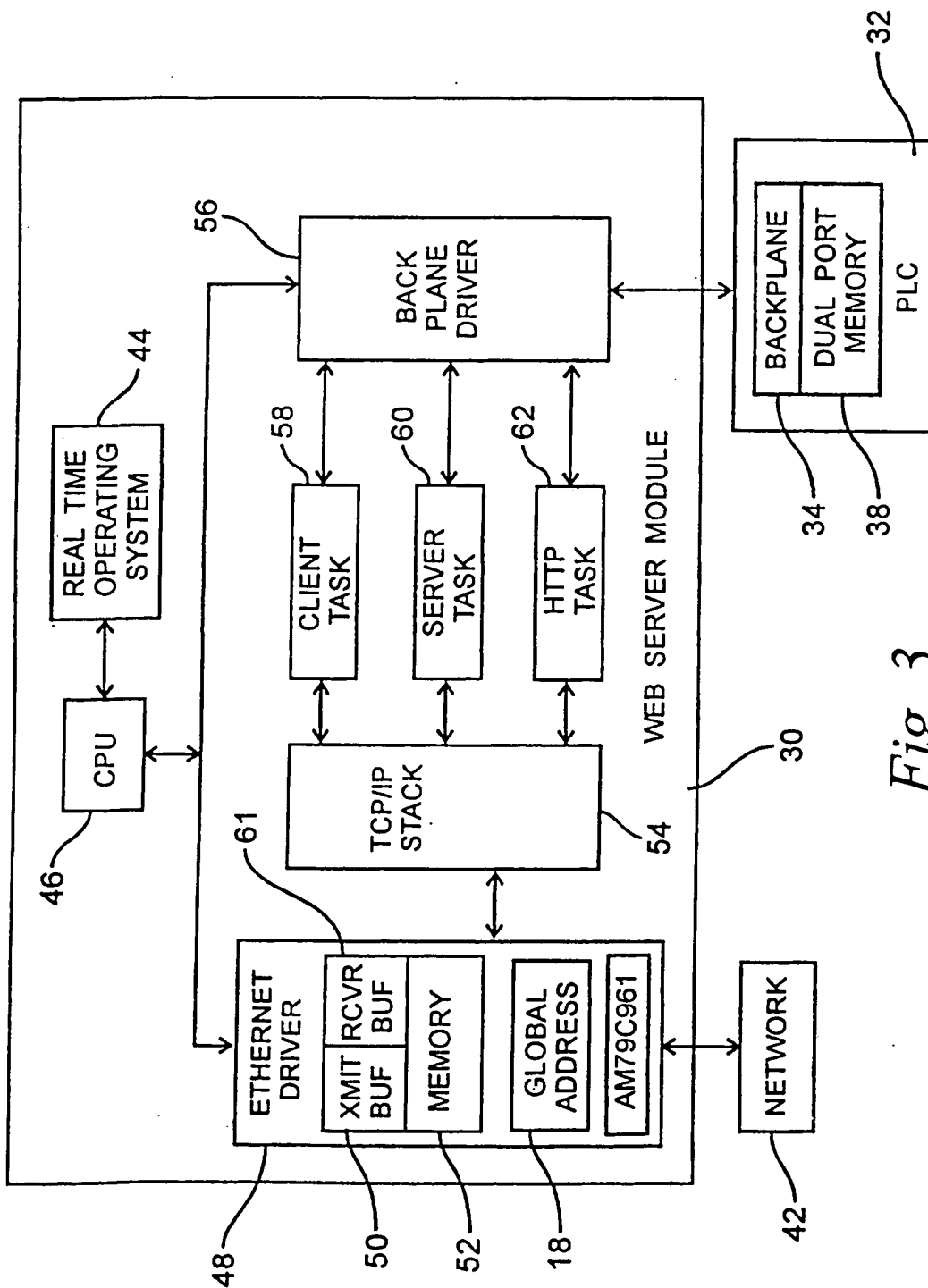


Fig. 3

THIS PAGE BLANK (USPTO)

4/4

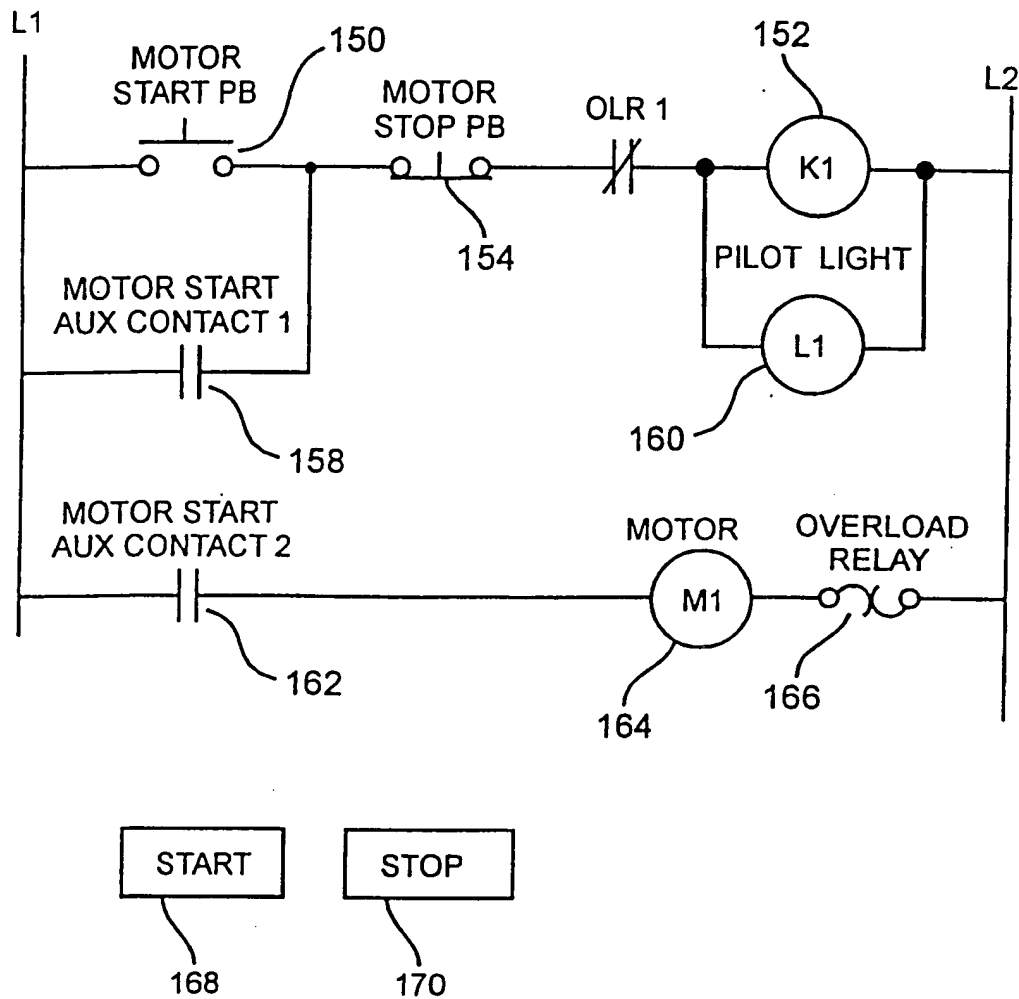


Fig. 4

THIS PAGE BLANK (USPTO)

(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau



(43) International Publication Date
12 July 2001 (12.07.2001)

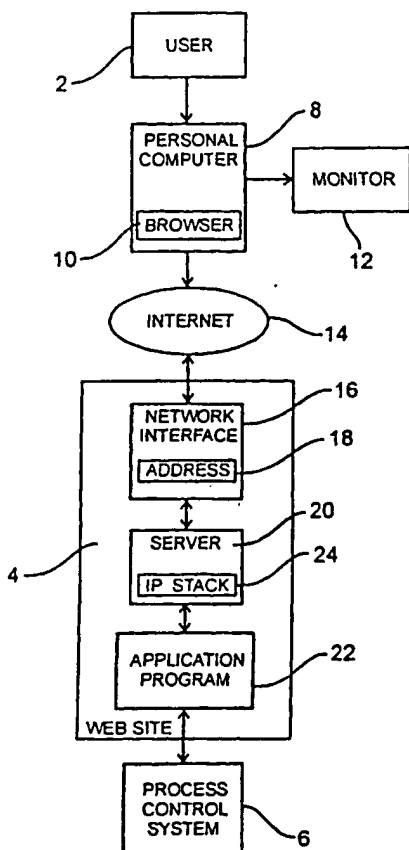
PCT

(10) International Publication Number
WO 01/50704 A3

- (51) International Patent Classification⁷: **H04L 29/06, G05B 19/00** (72) Inventors: **PAPADOPOULOS, A., Dean**; 11 Rooks Run, Groton, MA 01450 (US). **TANZMAN, Allan**; 37 Westsex Road, Newton Center, MA 02459 (US). **NAISMITH, Ronald, H.**; 42 Huckleberry Lane, North Andover, MA 01845 (US).
- (21) International Application Number: **PCT/US00/33215**
- (22) International Filing Date: 7 December 2000 (07.12.2000)
- (25) Filing Language: **English** (74) Agent: **GOLDEN, Larry, I.**; Square D Company, General Patent Counsel, 1415 South Roselle Road, Palatine, IL 60067 (US).
- (26) Publication Language: **English** (81) Designated States (*national*): **CA, MX.**
- (30) Priority Data: **09/477,113** 31 December 1999 (31.12.1999) **US** (84) Designated States (*regional*): European patent (AT, BE, CH, CY, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE, TR).
- (71) Applicant: **SCHNEIDER AUTOMATION INC.** [US/US]; One High Street, North Andover, MA 01845 (US). Published:
— with international search report

[Continued on next page]

(54) Title: DUAL ETHERNET STACK FOR MAXIMUM SPEED ACCESS TO A PLC



(57) Abstract: A control system includes an Internet web interface (16) to a network of at least one programmable logic control system (4) running an application program (22) for controlling output devices in response to status of input devices. The Web interface (16) runs Web pages from an Ethernet board coupled directly to the PLC back plane and includes an HTTP protocol interpreter, a PLC back plane driver, a TCP/IP stack, and an Ethernet board kernel. The Web interface provides access to the PLC back plane by a user at a remote location through the Internet. The interface translates the industry standard Ethernet, TCP/IP and HTTP protocols used on the Internet into data recognizable to the PLC. Using this interface, the user can retrieve all pertinent data regarding the operation of the programmable logic controller system.

WO 01/50704 A3

WO 01/50704 A3



(88) Date of publication of the international search report:
24 January 2002

For two-letter codes and other abbreviations, refer to the "Guidance Notes on Codes and Abbreviations" appearing at the beginning of each regular issue of the PCT Gazette.

INTERNATIONAL SEARCH REPORT

International Application No.

PCT/US 00/33215

A. CLASSIFICATION OF SUBJECT MATTER
 IPC 7 H04L29/06 G05B19/00

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
 IPC 7 H04L G05B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal, WPI Data, PAJ

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category *	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	WO 99 13388 A (SQUARE D CO) 18 March 1999 (1999-03-18) page 3, line 25 -page 4, line 4 page 6, line 25 -page 7, line 23 page 8, line 17 -page 11, line 3 page 13, line 8-13 page 15, line 3 -page 17, line 4 page 25, line 2-16 page 28, line 3-19 ----	1-20
A	WO 99 13418 A (SQUARE D CO) 18 March 1999 (1999-03-18) the whole document ----	1-20
A	US 5 710 708 A (WIEGAND JENS) 20 January 1998 (1998-01-20) column 2, line 31-44 -----	1

☐ Further documents are listed in the continuation of box C.

☒ Patent family members are listed in annex.

* Special categories of cited documents:

- *A* document defining the general state of the art which is not considered to be of particular relevance
- *E* earlier document but published on or after the international filing date
- *L* document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

- *T* later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- *X* document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- *Z* document member of the same patent family

Date of the actual completion of the international search

27 July 2001

Date of mailing of the international search report

02/08/2001

Name and mailing address of the ISA

European Patent Office, P.B. 5818 Patentlaan 2
 NL - 2280 HV Rijswijk
 Tel. (+31-70) 340-2040, Tx. 31 651 epo nl,
 Fax: (+31-70) 340-3016

Authorized officer

Dupuis, H

INTERNATIONAL SEARCH REPORT

Information on patent family members

International Application No

PCT/US 00/33215

Patent document cited in search report	Publication date	Patent family member(s)	Publication date
WO 9913388 A	18-03-1999	EP 0937283 A	25-08-1999
WO 9913418 A	18-03-1999	EP 0937289 A	25-08-1999
		US 6061603 A	09-05-2000
		US 6151625 A	21-11-2000
		US 2001003804 A	14-06-2001
US 5710708 A	20-01-1998	EP 0710904 A	08-05-1996
		CZ 9502786 A	15-05-1996
		DE 19539354 A	02-05-1996
		DE 59407059 D	12-11-1998
		IT MI952164 A	26-04-1996
		JP 8289377 A	01-11-1996